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High Throughput Integrated Technologies for Multimaterial Functional Micro Components (EU FP7 HINMICO 2013-2016)

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Abstract

The objective of the HINMICO project is the development and optimization of manufacturing processes for the production of high-added value high quality multi-material micro-components, with the possibility of additional, functionalities, through more integrated, efficient and cost-effective process chains.

Keywords: Micro-injection moulding, multi-material micro manufacturing, in-mould assembly, laser welding, metallization, in-line process monitoring, in-line metrology.

1. Introduction

In recent years, there has been an increasing trend towards miniaturization in many sectors of the European industry due to the extraordinary advantages and new possibilities that multi-material microsystems-based products can offer, becoming, in most cases, an economic and technological key factor for the majority of industrial applications. Highly miniaturized systems (in health care, automotive, communications) manufactured by a wide variety of materials and technologies (including the new concept of "converging technologies") represent a global market of several tens of B€ with a significant annual growth, and are mostly polymer-based micro-systems. The leading role in the European polymer replication industry is played by Small and Medium Enterprises (SMEs) (near to 40.000 enterprises) which employs around 2 million people and presents a turnover close to 200 B€. Even though the European industry is the worldwide technology leader, the increasing market demands imply the need of expansion of micro-fabrication process capabilities for mass manufacture multi-material micro-components and miniaturized parts incorporating functionalized micro or nano features, in order to achieve high quality products and significantly reduce the time to market and costs in order to succeed in this global market place.

2. The HINMICO project

The objective of the HINMICO project is the development and optimization of manufacturing processes to produce high quality multi-material micro-components, with the possibility of additional, functionalities, through more integrated, efficient and cheaper process chains (see Figure 1). The goals of HINMICO have been the development in four main domains: micro replication, high-throughput process chains, in-line monitoring, advanced functionality.

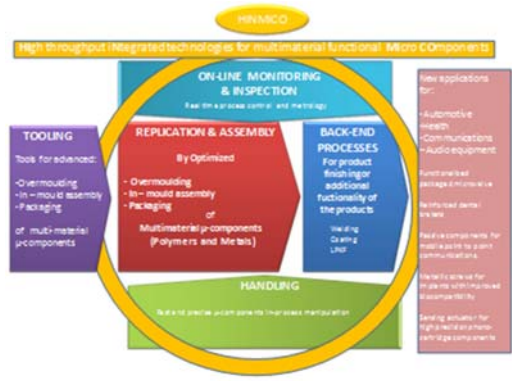

Figure 1: HINMICO project objectives.

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1) Fast and precise µ-replication-assembly processes with new tooling concepts/designs for processing high quality miniaturised multi-material parts and to fabricate:

• 3D multi-material µ-components (sensing actuator, dental implant …) using advanced materials by µ-injection moulding [1], [2], [3], [4], with µm resolution.

2) High-throughput process chain by the integration of the above mentioned µ-replication-assembly and back-end processes for product finishing or a complementary activation step, to fabricate multi-material functional devices:

• Integrated processes based on Micro-replication (over-moulding, in-mould assembly, packaging) utilising modules of e.g.: coating, laser welding and laser direct structuring.

• High speed and precision handling system for delicate µ-part including the feeding and accurate allocation in mould of in-lay parts and the placement of the injected multi-material components on the next stages within the process chain.

3) Global process chains with increased reliability (50%) and fabrication of high quality products:

• This requires on-line process monitoring and innovative on-line process inspection solutions.

4) High added value µ-devices with advanced functionalities:

• The production of multi-material functional µ-components will be validated through 5 industrial demonstrators in 3 different sectors (health, communications, automotive).

HINMICO has involved 16 partners from 7 European countries with a great participation of high-tech SMEs from various sectors (EuroOrtodoncia, Flann Microwave, Ortofon, Alicona, Flowdit, Pim Technologies , Mondragon Assembly, Ernst Wittner), industrial leaders (Wittmann-Battenfeld) and multidisciplinary research organisations covering the whole process chain (Tekniker, KIT, UoB, DTU, IDEKO, PEP, UC3M).

3. Industrial validation and demonstration

The validation of these new/upgraded process chains was realized through the production of different multi-material µ-devices demonstrators representing different sector of applications (mobility, health, audio equipment and information technology).

3.1. Mobility

FLOWDIT developed a micro-actuator dedicated to fluid flow control to minimize aerodynamic drag reduction and, therefore, the fuel consumption. The micro-actuator is packaged by a functionalized packaging, including the micro electrical input and the micro air input (see Figure 2).

3.2. Health

RHP Technology GmbH developed an implantable medical screw, with a functionalized porous metallic core with a bio-compatible thin polymer surface layer in order to stimulate cell growth and drug delivery (see Figure 3).

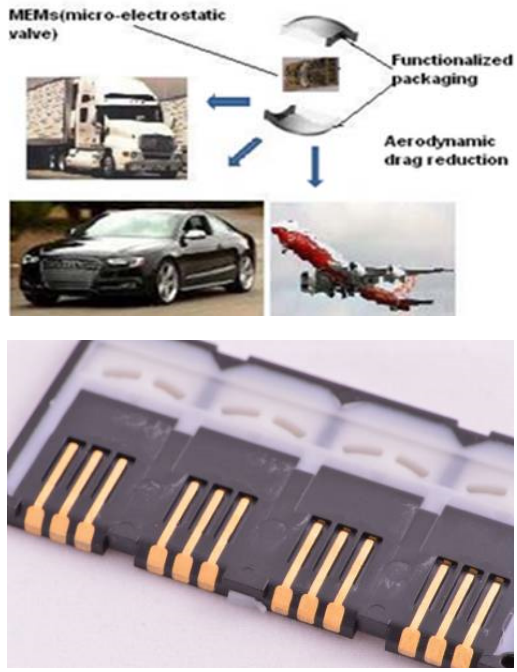

Figure 2: Micro-actuator for fluid flow control and drag reduction (top); overmoulded and plated functional micro packaging (bottom).

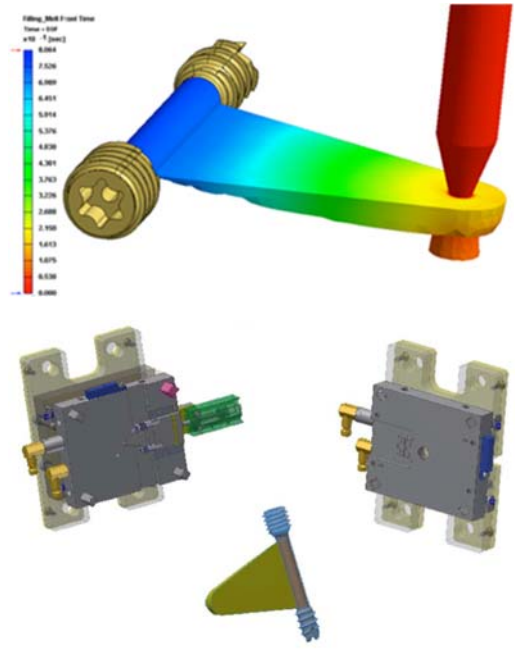

Figure 3: Filling simulation of polymer overmoulding for orthopedic implant (top); polymer overmoulding tool (bottom).

Euroortodoncia developed an improved polymer dental bracket with an embedded metallic reinforcement for withstand the torque force in the latest stages of the treatment (see Figure 4).

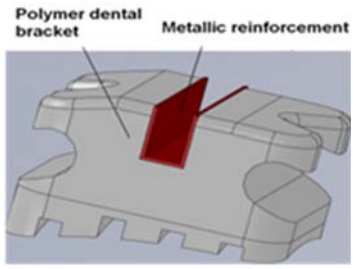

Figure 4: Polymer-metal micro insert moulded dental bracket.

3.3. Audio technology

Ortofon developed a complex three-dimensional multi-material sensing actuator for high-precision cartridge components. The product is composed an aluminium cantilever carrying a pre-assembled diamond tip, a polymer suspension ring and a micro magnetic shaft (see Figure 5).

Figure 5: Cartridge (top); multi-material micro sensing actuator produced by micro insert moulding: (1) magnet, (2) suspension ring, (3) cantilever tube, (4) diamond tip.

3.4. Information technology

Flann Microwave Limited developed passive microwave components (transmit/receive diplexers) for point to point communications for short-range high capacity urban mobile backhaul. The microwave components consist of a polymer replicated core with dimensions and tolerances depending on the working frequency with a metallic coating for high surface conductivity requirement (see Figure 6).

Figure 6: Injection moulded diplexer (left); plated diplexer (right).

4. Conclusion

The HINMICO project has made considerable progress on micro/nano-manufacturing towards intelligent, scalable and adaptable systems, enabling the cost-efficient, competitive and market-demand targeted production of functional multi-material micro devices (see Table 1). Applications ranging from small/medium volumes to high throughput have been demonstrated in pilot productions by the project industrial partners. The HINMICO project has successfully supported micro products and micro manufacturing processes development thus facilitating the access to target markets characterised by small or growing volumes.

Table 1: Impact of the HINMICO project.

	Expected Impact
Progress towards intelligent systems	• Online process monitoring: closed-loop µIM process control based on process parameters and product parameters (e.g. in-line measurements) • Fast setting up processes due to new close-loop µIM based on both process and product monitoring. • 100% product quality control with high-speed in-line 3D micro metrology. • Self-adapting high precision multi-material micro assembly injection moulding with total quality capability.
Scalable and adaptable	• Standardized process chains for multi-material micro products including multi-material µIM (adaptable to different materials), in-mould assembly, in-line metrology, product/process control. • Flexible process chains adaptable to different products and applications.
Cost efficient	• Fast production rate with high accuracy assembly and total quality control to ensure low production cost and high productivity.
Market demand	• Improved existing products with lower manufacturing costs and complementary markets. • New products at low cost for high volume applications.
Small, medium to high throughput	• Low fixed costs (moulds) for small volumes. • Low cost equipment due to flexible production unit cell components (micro injection moulding machine, handling/assembly re-programmable units, highly flexible metrology instrument).

Acknowledgements

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